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Published in:
Environmental Science and Pollution Research

DOI:
10.1007/s11356-019-05315-7

Publication date:
2019

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Note: The final version of this paper has been published, so can be cited as follows:

Li, H., Gozgor, G., Lau, C.K.M. and Paramati, S.R. (2019). Does tourism investment improve the energy efficiency in transportation and residential sectors? Evidence from the OECD economies. Environmental Science and Pollution Research (available online).

Does Tourism Investment Improve the Energy Efficiency in Transportation and Residential Sectors? Evidence from the OECD Economies

Abstract

This paper investigates the impact of tourism investments on energy efficiency across the transportation and residential sectors of 32 Organization for Economic Co-operation and Development economies. Using annual data from 1995 to 2012, we employ various panel econometric techniques to achieve the study objectives. Given the nature of variables, the paper applies panel autoregressive distributed lag models to estimate the long-run elasticities of energy intensity. The long-run estimates confirm that tourism investments play an essential role in improving energy efficiency across the transportation and residential sectors. Furthermore, the results show that both the foreign direct investment inflows and trade openness also play a considerable role in reducing energy uses across these sectors. Finally, the findings suggest that the tourism investments Granger cause energy efficiency of transportation and residential sectors in the short-run. Given these findings, the paper adds considerable value to the empirical literature and also provides various policy- and practical implications.

Keywords: Tourism investments; energy efficiency; transportation; residential; Organization for Economic Co-operation and Development economies; panel autoregressive distributed lag estimations

1. Introduction

Energy efficiency policies have an increasing precaution in the 21st century due to the effects of climate change. Energy efficiency policies can bring some advantages to economies in the aspects of the production process by reducing carbon dioxide emissions and fossil fuel energy consumption as well as providing security for energy supply. On the consumption side, energy efficiency policies can save the money of consumers (Costa-Campi et al., 2015). The recent evidence of Energy Information Administration (EIA, 2017) indicates that the level of carbon dioxide emissions related to energy consumption significantly reduced in the Organization for Economic Co-operation and Development (OECD) countries since 2008. The continuity of this trend requires an increase in energy efficiency (i.e., the lower fuel economy)[1] especially in buildings and the transportation sector (Scott et al., 2016).[2] In short, energy efficiency can not only be a significant factor for providing sustainable economic growth but also for raising the green global economy. However, these issues depend on efficient energy and infrastructure policies; and therefore, it is needed to understand the determinants of energy efficiency. For this purpose, the paper aims to analyze how the development of the tourism industry affects energy efficiency in a panel data sample of 32 OECD countries.

Given that without new energy policies, the CO_2 emissions, due to energy demand, are projected to increase by 28% from 2015 to 2040 (EIA, 2017).[3] Besides, according to the EIA (2017), energy consumption in the OECD countries is expected to increase by 9% from 2015 to 2040. The industrial sector has the largest share (more than 50%) of energy consumption in 2015 and expected to be around 50% even by 2040. It is important to note that the energy

1 Energy efficiency usually refers to the use of technology within the energy related products. Therefore, energy efficiency helps the economies to mitigate the growth of carbon emissions (Apergis et al., 2018).

2 The transportation sector accounts for 55% of the fuel consumption in 2015 and it is expected to be around the share of 60% by 2040 (EIA, 2017). Therefore, transportation is the largest consumer of fuels due to energy use for travel and freight services (Craig et al., 2013). The growth rate of fuel consumption related to transportation is expected to be higher than their use in other objectives for the period from 2015 to 2040 (EIA, 2017).

3 Half of this increase is expected to occur from China and India, where strong economic growth causes a higher demand for energy (Chung et al., 2013).

demand in residential and transportation sectors is expected to increase much quicker than the industrial sector: For instance, the expected growth rate of energy consumption for the industry is 0.7%, while it is 1.1% for both the residential and transportation sectors in the world (EIA, 2017). The difference between the growth rate between industry and transportation is higher in the OECD countries, and the growth rate is projected to be around 0.2% for the industry and 0.5% for residential and transportation sectors, respectively. The European Union (EU) has recently aimed to improve energy efficiency, and they have specifically targeted an annual reduction of 1.5% in domestic energy sales (EIA, 2017). This target mainly relates to the evidence that economic activities and production in the OECD countries will move from energy-intensive industries to more service-oriented sectors, including tourism (Yuan et al., 2017). As a consequence, energy uses in buildings and transportation sectors for the OECD countries is projected to decline in the forthcoming decades, if the required new energy efficiency policies will be implemented effectively.

However, relatively underdeveloped infrastructures and large rural population (lack of shift from rural to urban areas) can negatively affect the development of energy efficiency in the residential and transportation sectors. It is also well argued that tourism contributes to higher energy consumption and carbon dioxide emissions. Hence, the tourism investments can be considered to play an essential role in minimizing energy uses by adopting the most advanced technologies in the tourism sector and making use of energy efficiency strategies (Alam and Paramati, 2017; Paramati et al., 2018; Shiftan et al., 2003). Keeping this view in mind, policymakers and government officials of the OECD economies have initiated sustainable tourism investments in their economies. Indeed, tourism investments are aimed to improve energy efficiency by adopting advanced technologies in energy uses across the residential and transportation sectors and also building the hotels and restaurants in an environmentally friendly way. These factors may assist those economies in minimizing the use of energy and the growth of CO_2 emissions. More specifically, hotels and other tourism-related services have significant potential for implementing energy efficiency measures and utilizing renewable energy sources. However, energy efficiency measures and renewable energy sources require new technology; and therefore, the investments in tourism facilities are crucial for understanding the potential gains of energy efficiency measures and renewable energy sources. At this stage, promoting energy efficiency in hotels can also create benefits not only for the overall performance of the economy and the objectives of the green economy but also it can enhance the image of hotels and decrease the operational costs of tourism facilities and the tourism-related activities. A lower level of operating expenses can increase the competitiveness of the tourism sector in the global area. However, it is noteworthy to mention that promoting environmental awareness to the customers is also an essential aspect of improving energy efficiency since the demand side of the market can also be a significant determinant factor.

Globalization can also be one of the significant factors to drive the customer demand for energy efficiency measures in the tourism facilities. The impact of globalization indicators is mainly due to an issue that globalization increases consumers' desire for goods and services and producers become further integrated into global supply chains. Thus it can significantly affect energy efficiency. Also, these indicators (foreign direct investment (FDI) and trade openness) can also bring technologies from other countries to the OECD countries; hence these global factors can further improve energy efficiency. To control the effects of globalization over the study period, the models include the FDI inflows and trade openness, which can play a considerable role in energy efficiency.

Given this backdrop, the paper aims to examine the impact of tourism investments on energy efficiency across the residential and transportation sectors in 32 OECD economies using annual data from 1995 to 2012. The results from the long-run elasticities show that tourism investments improve energy efficiency across the transportation and residential sectors. More specially, the growth of tourism investments helps the transportation and residential sectors to reduce the use of energy to produce one unit of economic output. Similarly, the paper demonstrates that the growth in FDI inflows and trade openness also improve energy efficiency in the transportation and residential sectors of the OECD economies. The findings from short-run causalities indicate that the tourism investments Granger cause the use of energy in transportation and residential sectors, while there is no evidence of reverse causality. Given these findings, tourism investments are playing an essential role in the tourism industry to improve energy efficiency across the residential and transportation sectors. Therefore, the policymakers and government officials of these economies should further implement sustainable tourism policies, including initiating further tourism investments in the industry. All these factors can assist the OECD economies in ensuring sustainable tourism growth. To the best of authors' knowledge, this paper is the first cross-country study to investigate the effect of tourism investments on energy efficiency. Hence, the article adds significant value to the empirical literature and also to the policies and practical implications.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature on the determinants of energy efficiency. Section 3 explains the nature of data, measurement, the empirical models, and the econometric methodology. Section 4 discusses the observed results. Section 5 provides a detailed discussion of the findings and the relevant policy and practical implications. Finally, the conclusion of the paper is discussed in Section 6.

2. Literature Review

Various papers in the literature examine the determinants of energy efficiency across the industry (manufacturing), residential, and transportation sectors. Most of those papers based on the survey data at the firm level, and they generally focus on a specific country or a region. For example, Abadie et al. (2012) and Blass et al. (2014) use the data for the small and the medium manufacturing (industrial) enterprises in the United States (U.S.) for the period from 1984 to 2009, while Costa-Campi et al. (2015) consider data for the Spanish firms in manufacturing over the period 2008–2011. These papers observe that innovative behavior of the firms can provide energy efficiency and a decline of environmental degradation are among the leading objective of innovation.[4] Following this branch of literature, the empirical models consider the FDI inflows and trade openness as benchmark indicators of innovation, which are the potential drivers of energy efficiency across residential and transportation sectors in the OECD countries. Furthermore, these indicators (FDI inflows and trade openness) also account for the globalization effect on energy efficiency. According to Dreher (2006) and Gozgor (2018), globalization increases consumers' demand for goods and services (measured by the trade openness), and producers become further integrated into global supply chains (measured by the FDI inflows). In line with these findings, the models test the hypothesis whether the trade openness and the FDI inflows can significantly affect the energy efficiency across residential buildings and transportation sector. In addition, since there is a positive correlation between per capita gross domestic product (GDP) and the probability of investing in energy technologies in residential buildings and transportation sector is observed in the previous literature (see e.g., Long, 1993; Mills and Schleich, 2012; Nair et al., 2010); hence the empirical models include the per capita GDP in the estimations.

Indeed, the tourism sector is a significant part of the world economy as it not only provides much employment and income opportunities for the local community but also provides revenues for the local and national governments and even enormous foreign

4 See Liu and Lin (2018), and Stephan and Stephan (2016) for a detailed review of the related literature on the determinants of energy efficiency in residential and transportation sectors in various countries, including BRIC, the European Union (EU), G-7, Iran, Mexico, the OECD economies, South Korea, Spain, and the U.S.

exchange reserves (Alam and Paramati, 2016). As a result of increasing tourism activities around the world, every year, millions of tourists travel to vast distances (Gössling et al., 2013). Those millions of travelers stay in hotels, which consume a significant amount of energy (Bohdanowicz et al., 2001). At this point, the hospitality industry is the largest business in the globe, and the energy used in the hospitality industry produces a significant amount of greenhouse gas emissions (Babaei et al., 2015).

At this point, there are only a few papers which investigate the effects of tourism indicators on energy efficiency measures. For instance, Becken and Cavanagh (2003) analyze the energy consumption of the tourism sector in New Zealand during 1999 and 2001. The authors provide potential implications for energy efficiency of vehicles and accommodation providers. In a further study, Becken and Hay (2007) discuss the potential risks and opportunities in the tourism sector to affect the pattern of climate change, including energy efficiency measures. In their seminal paper, Gössling et al. (2005) conclude that limiting the consumption of fossil-related energy source is the main issue for achieving the objectives of sustainable tourism development. Finally, Scott et al. (2016) illustrate that the consumption of fossil fuels is associated with the emissions of greenhouse and it is the leading environmental problem. The increasing greenhouse gases can have a significant adverse effect on climate change and also on the tourism industry. Indeed, hotels and tourism-related services have more considerable potential for implementing energy efficiency measures and utilizing renewable energy sources. However, implementing energy efficiency measures and using renewable energy sources require new technology (Gozgor, 2016). Therefore, tourism investments (improvements) can enhance existing technologies for saving energy to address environmental degradation, thus the pattern of global climate change (Paramati et al., 2018). Therefore, there could be a significant link between tourism investments and energy efficiency due to the residential (e.g., hotels) and transportation activities (e.g., air, rail, road, and sea).

To add these papers, the recent empirical study by Alam and Paramati (2017) focus on the effects of tourism investments on tourism development and the level of carbon dioxide emissions in a panel of 10 major tourism-based economies over the period 1995–2013. According to the results, tourism investments not only promote the growth of the tourism industry but also help to reduce CO_2 emissions.[5] In line with the model of Alam and Paramati (2017), our paper considers the tourism investments as the leading indicator of tourism development, but it focuses on the indirect effects of tourism investments on environmental quality by enhancing energy efficiency in residential and transportation sectors of the OECD countries.

Also, Hochman and Timilsina (2017) investigate the barriers on the implementation and adoption of energy-efficient technologies for commercial and industrial firms in Ukraine, and they conclude that lack of knowledge and awareness are significant barriers to the approval of energy-efficient technologies in those firms. However, it is also argued that the high barrier to energy efficiency is minimized for tourism sector because the hospitality businesses have to maintain the positive image, including more green and eco-lodgings and transportation services (Babaei et al., 2015). Therefore, the investments in energy-efficient technologies in the tourism sector can save energy consumption, improve productivity, and reduce carbon dioxide emissions from the productive areas. Increased investment in greening the tourism sector can contribute to improved efficiency in resource use and minimize environmental degradation, attribute to the expectations of tourists regarding responsible natural resource management and also the needs of communities that support or are affected

5 A recent study by Paramati et al. (2018) also examined the effect of tourism investments on tourism development and CO_2 emissions in a panel 28 EU countries. Their results established that the growth in tourism investments has considerable positive and negative effects on tourism development and CO_2 emissions, respectively. Further, the authors suggest that tourism investments in the EU nations not only promoting sustainable tourism development but also ensuring low carbon economies.

by tourism projects and the environment (United Nations Environment Program, 2011). However, the hypothesis of the causality running from tourism investment to energy efficiency as put forward by the above explanations has not yet investigated in the literature.

To conclude the literature review, we observed that there are various papers, which examine the determinants of energy efficiency; however, the previous studies neglected the effects of tourism investments on energy efficiency across the residential and the transportation sectors. Considering the role of tourism investments as the benchmark indicator of tourism development on energy efficiency, we provide the first empirical evidence on this subject. For this purpose, this study focuses on a panel of 32 OECD countries throughout 1995–2012. To be consistent with the previous literature on energy efficiency, we include the FDI inflows, trade openness, and per capita income in the models along with the tourism investments. Therefore, the findings derived from this paper have important practical implications and adds new knowledge to the empirical literature.

3. Data, Models, and Methodology

3.1. Data Description and Empirical Models

The present paper collects yearly data from 1995 to 2012 from 32 OECD economies, such as Australia, Austria, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea Republic, Latvia, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom (UK), and the U.S. The balanced panel dataset on the selected variables and countries of the OECD economies is only available from 1995 to 2012; hence the sample period of the study is determined by the availability of annual data.

In this paper, it is aimed to empirically investigate the impact of tourism investments on energy efficiency across transportation, residential, and overall economy by accounting other potential determinants in the models, such as FDI net inflows, per capita income, and trade openness. The tourism investments are measured in a million USD (real prices) (TI)[6], the energy intensity of the transportation sector is in MJ/2011 USD PPP (TEI), energy intensity of residential sector is in GJ/household (REI), energy intensity of overall economy is of final energy in MJ/2011 USD PPP (OEI), FDI, net inflows as a percentage of GDP (FDI), real GDP per capita income in constant 2010 USD (PI). Finally, trade openness is the total exports and imports as a percentage of GDP (TO). We obtain the required data on TI from the World Travel and Tourism Council (WTTC), while data on TEI, REI, and OEI downloaded from the "Sustainable Energy for All" dataset of the World Bank; and finally, data on PI, FDI and TO collected from the "World Development Indicators (WDI)" dataset of the World Bank. As implied from the description of the variables, they measured in different units; hence, the study converts all these variables into natural logarithms before the empirical estimations.

The objective of this research is to empirically investigate the impact of tourism investment on energy efficiency of transportation, residential, and overall economy of the 32 OECD economies. To achieve the above objectives, following traditional energy demand models, we use the following equations:

$$TEI_{it} = f\,(FDI_{it}, PI_{it}, TO_{it}, TI_{it}, v_i) \tag{1}$$

$$REI_{it} = f\,(FDI_{it}, PI_{it}, TO_{it}, TI_{it}, v_i) \tag{2}$$

$$OEI_{it} = f\,(FDI_{it}, PI_{it}, TO_{it}, TI_{it}, v_i) \tag{3}$$

In Eq. (1), (2), and (3), where TEI, REI, OEI, FDI, PI, TO, and TI indicate the energy efficiency of transportation, residential, overall economy, FDI inflows, per capita income, trade openness and tourism investments, respectively. Similarly, v_i represents for the

6 The definition of tourism investment is that it includes capital investment spending by all industries directly involved in Travel and Tourism. This also constitutes investment spending by other industries on specific tourism assets such as new visitor accommodation and passenger transport equipment, as well restaurants and leisure facilities for specific tourism use. It is also important to highlight that we do not have information on how much is the share of FDI in tourism investments for each country. Therefore, the reader may consider this as a limitation of the study.

individual (country) fixed-effects; and *i* and *t* capture the cross-section and period, respectively.

3.2. Econometric Methodology

To begin the investigation, we examine the order of integration of variables using several panel unit root tests. It is important to understand the order of integration of the variables before employing any econometric technique. This knowledge will help us to choose the appropriate econometric methodology. The paper makes use of five-panel unit root tests that examine common, as well as individual, unit root processes. For instance, the common unit root process is analyzed using Levin et al. (2002) and Breitung (2000) tests, while the individual unit root process is investigated using Im et al. (2003) and two Fisher type tests, such as the Augmented Dickey and Fuller (ADF) and Phillips and Perron (PP). The Fisher-type unit root tests are developed based on the approach suggested by Maddala and Wu (1999). All of these unit root tests follow the null hypothesis of a unit root as against the alternative hypothesis of no unit root in general.

The long-run energy efficiency elasticities of transportation, residential, and the overall economy are investigated using the panel autoregressive distributed lag (ARDL) models. The significance of the ARDL method is that it can be applied to the model, which possesses a different order of integration of the variables, that is, either I (0) or I (1). Therefore, given the nature of the variables, the ARDL model is more appropriate to examine the long-run energy efficiency elasticities.[7] To this end, the paper applies the panel approach suggested by Pesaran et al. (1999). This panel ARDL approach assumes the cross-sectional independence, implying that the disturbances are independently distributed across units and over time with the zero mean and the constant variances. The appropriate lag length for this test is selected based on the Akaike Information Criteria (AIC).

7 Given that it is estimated the single cointegrating vector to investigate long-run estimates.

Finally, the paper applies the short-run bivariate panel non-causality test to examine the direction of causal relationships among the variables of energy efficiency of transportation, residential, and overall economy, as well as the FDI inflows, per capita income, and trade openness. For this reason, the paper focuses on the approach suggested by Dumitrescu and Hurlin (2012). This test requires all the variables to be stationary; hence, we applied to the first difference data series of these variables. The null hypothesis of no causality tested against the alternative hypothesis of causality at least for a few cross-sections. The Wald statistics are computed separately for each cross-section, and the panel test value obtained by taking the cross-sectional average of the individual Wald statistics.

4. Empirical Results

4.1. Preliminary Analysis of the Data

Firstly, the paper provides a preliminary analysis of the variables included in the empirical models. Table 1 shows summary statistics on the individual OECD economies for the period from 1995 to 2012. Among 32 OECD economies, we observed that the energy efficiency in transportation, residential, and overall economy are significantly higher in the countries like Turkey and Mexico, while it is lower in the U.S. and Iceland, respectively. Likewise, Japan had received the lowest FDI inflows among the considered OECD economies, whereas the Netherlands received the highest. Japan also has the lowest trade openness among these countries. The per capita income ranges from 8,597 US$ (Mexico) to 83,980 US$ (Norway). Finally, the tourism investments also vary across these OECD economies; specifically, it ranges from 183 million US$ (Latvia) to 135,466 million US$ (the US). Overall, the OECD countries invest 10,640 million US$ per year, on average, during the sample period.

[Insert Table 1 around here]

Table 2 reports the compounded annual growth rates on the individual OECD economies for the period of 1995 to 2012. It is interesting to notice that the country that has significant growth in tourism investment is associated with the largest reduction in the overall energy intensity. For instance, Latvia has shown a growth rate of 13.34% in tourism investments, whereas it has shown the highest level, among the considered countries, of reduction in overall energy intensity, i.e., 3.84%. On the other hand, Iceland experienced the lowest growth in tourism investment, i.e. 0.54% only, whereas its reduction in the overall energy intensity is only 0.01%, and it is the lowest among all 32 OECD countries. However, some other countries such as Greece, Japan, the Netherlands, and Spain have shown negative growth in tourism investments. It is also important to note that all of the OECD economies have shown the positive growth rate in per capita income.

[Insert Table 2 around here]

4.2. Findings on Order of Integration of the Variables

To begin the empirical investigation, we firstly investigated the order of integration of the selected variables. We used several panel unit root tests since it is an important step in the appropriate modeling strategy for the subsequent empirical analyses. Therefore, it is applied five versions of panel unit root tests, namely LLC (Levin, Lin and Chu, 2002), Breitung test (Breitung, 2002), the IPS (Im, Pesaran and Shin, 2003) and the Fisher ADF and the Fisher PP (Maddala and Wu, 1999; Choi, 2001). The results of these tests on the level and the first difference data series are shown in Table 3. All panel unit root tests have been estimated by including constant and trend variables. The results of these panel unit root tests show the mixed order of integration. The LLC test indicates that all variables are stationary except the overall energy efficiency and the real GDP per capita. The Breitung test, however, indicates that all variables are non-stationary except the FDI, trade openness, and tourism investments. The IPS test and the ADF test indicate that all variables are stationary except the real GDP per capita. The PP test indicates that the overall energy efficiency, the real GDP per capita, and the trade openness are non-stationary at the levels. Therefore, it is safe to conclude that the FDI and the tourism investments are stationary variables, but the evidence is mixed for others. The results, therefore, suggest that some of the variables are stationary at the levels, while some other variables are non-stationary. Given that, the paper applies these unit root tests on the first order difference data series and the findings show that the null hypothesis is strongly rejected for all of the variables. Based on these findings, we concluded that the variables of this study have a mixed order of integration, i.e., either I (0) or I (1).

[Insert Table 3 around here]

4.3. Findings of Long-run Energy Efficiency Elasticities

Since above panel unit root tests confirm the mixed order of integration of the selected variables; hence, the study uses the panel ARDL model of Pesaran et al. (1999) to investigate the long-run elasticities of the energy efficiency across transportation, residential, and overall economy of the 32 OECD economies. More specifically, the paper investigates the impact of tourism investments on energy efficiency by accounting other potential determinants, such as per capita income, FDI inflows, and trade openness in the models. The significance of the panel ARDL method is that it allows estimating long-run parameters even in the presence of a mixed order of integration of the variables. Furthermore, it accommodates endogeneity concerns that may occur in the models. We present the findings of the panel ARDL models in Table 4. The results indicate that tourism investments have played a considerable role in improving energy efficiency across transportation, residential, and the overall economy.

[Insert Table 4 around here]

According to the results presented in Table 4, a 1 percent growth in tourism investment reduces the energy use in transportation, residential, and overall economy by 0.024, 0.078 and 0.042 percent, respectively. It implies that higher tourism investments lead to higher energy efficiency across the transportation, residential, and overall economy of the OECD economies. Furthermore, the results establish that the growth in FDI inflows and trade openness also improve the energy efficiencies in these economies. However, the increase in per capita income raises energy use across transportation and residential sectors but reduces the overall energy consumption in the economy.

The long-run elasticities indicate that the tourism investments, along with the FDI inflows and trade openness (except in the case of the overall energy efficiency) significantly promotes energy efficiency in the OECD countries, while the real GDP per capita growth promotes the overall energy efficiency, but adversely affect the energy efficiency in transportation and residential sectors. These results show that tourism investments have a significant positive impact on energy efficiency across the considered industries in the paper.

4.4. Findings on Short-run Causalities

Finally, the paper examines short-run causalities among the variables of energy efficiency indicators, the GDP per capita, the FDI inflows, the trade openness, and the tourism investments. The study uses heterogeneous causality technique of Dumitrescu and Hurlin (2012) to estimate the short-run dynamics among the variables. We display the short-run causalities in Table 5.

[Insert Table 5 around here]

The causality test results demonstrate that the tourism investments Granger cause the energy efficiency of transportation and residential sectors, but it has no significant impact on the energy efficiency of the overall economy in the short-run. Similarly, the results display bidirectional causality between FDI inflows and energy efficiency of transportation and also between per capita income and energy efficiency of transportation. On the other hand, we find that the unidirectional causality that runs from per capita and trade openness to the energy efficiency of the residential and overall economy. Hence, these short-run findings on causal relationships among the consider variables imply that the tourism investments play an essential role to affect the energy efficiency of transportation and residential sectors. Similarly, the per capita income and trade openness also cause energy efficiency.

5. Discussion and Policy Implications

Based on the empirical findings from long-run and short-run estimations, it suggests that tourism development (investments) has a positive environmental impact on the economy given the adoption of more environmentally-friendly strategies and technologies. Besides, the empirical results demonstrate that it is possible to invest in tourism to offset tourism-based carbon dioxide emissions, especially in the residential and transportation sectors. Several policy implications in regards to enhancing the level of energy efficiency in the OECD economies can derive from the long-run estimates. The findings establish that the tourism development not only provides an opportunity for residents to participate in direct employment but also enhances energy efficiency through the investment in renewable energy and energy efficiency technologies both in residential and transportation sectors.

Several previous studies suggest that tourism development leads to higher pollution and environmental degradation (Raza et al., 2017; Sun, 2016; Zhang and Gao, 2016). However, the development of low-carbon and sustainable tourism (i.e., investment in the industry) can ensure that it develops sustainability for the benefits of the local economy by enhancing national energy efficiency both in residential and transportation sectors (e.g., the usage of green energy and energy efficiency practices in hotels and hospitality industry, including pubs and restaurants). The energy efficiency in the whole economy can provide through several successful businesses approaches in accordance with the corporate social responsibility (CSR) principles, including adopting and implementing sustainable supply-chain initiatives, and focusing on business to business marketing rather than business to consumer marketing (Dodds and Joppe, 2005), and fostering clean energy sources (Sun, 2016).

Besides, the results are in line with existing literature, indicating that both the FDI inflows and the trade openness play a considerable role in reducing energy uses across the sectors in 32 OECD economies (Lee, 2013; Mielnik and Goldemberg, 2002; Zheng et al., 2011). These results imply that free trade and the promotion of inward FDI, in particular, encourage more efficient energy use to combat CO_2 emissions (Gozgor, 2017; Sbia et al., 2014). For instance, the real estate projects of artificial islands are huge energy-intensive projects; therefore, the government of the United Arab Emirates (UAE) facilitates the FDI inflows to green energy projects. These findings imply that the policymakers and government officials should consider different policies for different sectoral FDI since the FDI can be a source of innovation in promoting energy efficiency, but the outcome varies in magnitude and significance by the sectoral FDI (Doytch and Narayan, 2016).

The established conclusion is that investments in the tourism sector enhance the energy efficiency for the economy. Therefore, the policymakers of the OECD countries should provide the incentives in the form of subsidies and financial support to the tourism industry to replace older machines and facilities with more efficient models, improving operational and infrastructure use, and adopting more of clean energy sources. The policymakers in government should also recognize that the above environment-friendly business practices can reduce the carbon dioxide emission levels in these countries by avoiding or reducing the use of fossil fuel energy and benefit the well-being of the local communities. Moreover, the business owners and managers should also realize that more efficient use of energy not only result in a reduction of operating costs but also attracts more international tourists, especially from the developed countries.

Given the above findings, policymakers should initiate more of sustainable tourism development policies, which may assist those countries in enhancing energy efficiency and reducing energy intensity in the long run. Equally important, the government should develop holistic and comprehensive tourism development strategies in partnership with the community and industry stakeholders (Dodds and Joppe, 2005). For instance, the Green Lights Program between "Green Lights Partner" and the United States Environmental Protection Agency (USEPA) encourages the use of energy-efficient lighting.

Given the above evidence and arguments, we suggest that the policymakers, government officials, travel agencies, and stakeholders in the industry should realize the substantial benefit of the tourism investments and use of renewable energy for the general enhancement of energy efficiency across the OECD countries. Therefore, political leaders should consider the tourism investment and hence energy efficiency as an essential tool in their energy policy portfolio. Among other areas, government officers should initiate policies to promote sustainable tourism investments and the procedures related to the promotion and use of renewable energy sources. These policies may include information provision and energy audits from the government officials as the energy efficiency investments are affordable to small- and medium-sized enterprises due to a wide range of sophisticated technologies and services, which are difficult to determine their quality either before or after purchase. Consequently, the information costs of obtaining and processing information on the energy efficiency can be high (Jollands et al., 2010). Besides, the lack of information, knowledge, and awareness are significant barriers to the adoption of energy-efficient technologies (Hochman and Timilsina, 2017). The difficult access to financing is another barrier, which further impedes investment in these technologies, especially for the small-and-medium-sized enterprises and without easy access to funding, many energy-efficient investments are unlikely to be implemented (Hochman and Timilsina, 2017; Jollands et al., 2010). Nevertheless, the commitment to sustainable development from the industry and government level is definite, but not yet decisive in the choice of customers.

6. Conclusion

The paper analyzed the impact of tourism investments on the energy efficiency of the transportation, residential, and overall economy in a panel of 32 OECD countries. Using annual data from 1995 to 2012, we employed various panel econometric techniques to achieve the research objectives. Given the nature of variables, the paper applied the panel ARDL models to estimate the long-run energy intensity elasticities. According to the long-run estimations, tourism investments play an essential role in improving energy efficiency across transportation and residential sectors. Furthermore, we find that both the FDI inflows and trade openness play a considerable role in reducing energy uses across these sectors. Finally, we observed that tourism investments cause energy efficiency both in the residential and transportation industries in the short-run. Given these findings, the paper provided new empirical knowledge on the nexus between tourism investments and energy efficiency by discussing various policies and practical implications. Future research may focus on country cases, especially large developing economies (e.g. China and India), the most-visited developing countries (e.g. Mexico, and Thailand, Turkey), or the small-island countries (e.g. the Maldives), which can be ideal sample countries in order to analyze the relationship between tourism indicators and energy efficiency.

References

Abadie, L.M., Ortiz, R.A., & Galarraga, I. (2012). Determinants of Energy Efficiency Investments in the US. *Energy Policy*, 45, 551–566.

Alam, M.S., & Paramati, S. R. (2016). The Impact of Tourism on Income Inequality in Developing Economies: Does Kuznets Curve Hypothesis Exist? *Annals of Tourism Research, 61*, 111–126.

Alam, M.S., & Paramati, S.R. (2017). The Dynamic Role of Tourism Investment on Tourism Development and CO_2 Emissions. *Annals of Tourism Research*, 66, 213–215.

Apergis, N., Can, M., Gozgor, G., & Lau, C.K.M. (2018). Effects of Export Concentration on CO_2 Emissions in Developed Countries: An Empirical Analysis. *Environmental Science and Pollution Research*, 25 (14), 14106–14116.

Babaei, T., Abdi, H., Lim, C.P., & Nahavandi, S. (2015). A Study and a Directory of Energy Consumption Data Sets of Buildings. *Energy and Buildings*, 94, 91–99.

Becken, S., & Cavanagh, J.A. (2003). Energy Efficiency Trend Analysis of the Tourism Sector. *Landcare Research Contract Report*, No: LC0203/180, Prepared for the Energy Efficiency and Conservation Authority.

Becken, S., & Hay, J.E. (2007). *Tourism and Climate Change: Risks and Opportunities*. Volume 1, Multilingual Matters: Bristol.

Blass, V., Corbett, C.J., Delmas, M.A., & Muthulingam, S. (2014). Top Management and the Adoption of Energy Efficiency Practices: Evidence from Small and Medium-sized Manufacturing Firms in the US. *Energy*, 65, 560–571.

Bohdanowicz, P., Churie-Kallhauge, A., Martinac, I., & Rezachek, D. (2001). Energy-efficiency and Conservation in Hotels–towards Sustainable Tourism. *4th International Symposium on Architecture in Asia and the Pacific*: Hawaii, HN.

Breitung, J. (2002). Nonparametric Tests for Unit Roots and Cointegration. *Journal of Econometrics*, 108 (2), 343–363.

Choi, I. (2001). Unit Root Tests for Panel Data. *Journal of International Money and Finance*, 20 (2), 249–272.

Chung, W., Zhou, G., & Yeung, I.M.H. (2013). A Study of Energy Efficiency of Transport Sector in China from 2003 to 2009. *Applied Energy*, 112, 1066–1077.

Costa-Campi, M.T., García-Quevedo, J., & Segarra, A. (2015). Energy Efficiency Determinants: An Empirical Analysis of Spanish Innovative Firms. *Energy Policy*, 83, 229–239.

Craig, A.J., Blanco, E.E., & Sheffi, Y. (2013). Estimating the CO_2 Intensity of Intermodal Freight Transportation. *Transportation Research Part D: Transport and Environment*, 22, 49–53.

Dodds, R., & Joppe, M. (2005). *CSR in the Tourism Industry? The Status of and Potential for Certification, Codes of Conduct and Guidelines*. IFC/World Bank: Washington, DC.

Doytch, N., & Narayan, S. (2016). Does FDI Influence Renewable Energy Consumption? An Analysis of Sectoral FDI Impact on Renewable and Non-renewable Industrial Energy Consumption. *Energy Economics*, 54, 291–301.

Dreher, A. (2006). Does Globalization Affect Growth? Evidence from a New Index of Globalization. *Applied Economics*, 38 (10), 1091–1110.

Dumitrescu, E.I., & Hurlin, C. (2012). Testing for Granger Non-causality in Heterogeneous Panels. *Economic Modelling*, 29 (4), 1450–1460.

Energy Information Administration (EIA). *International Energy Outlook 2017*. U.S. Energy Information Administration: Washington, DC.

Gozgor, G. (2016). Are Shocks to Renewable Energy Consumption Permanent or Transitory? An Empirical Investigation for Brazil, China, and India. *Renewable and Sustainable Energy Reviews*, 66, 913–919.

Gozgor, G. (2017). Does Trade Matter for Carbon Emissions in OECD Countries? Evidence from a New Trade Openness Measure. *Environmental Science and Pollution Research*, 24 (36), 27813–27821.

Gozgor, G. (2018). Robustness of the KOF Index of Economic Globalisation. *The World Economy*, 41 (2), 414–430.

Gössling, S., Peeters, P., Ceron, J-P., Dubois, G., Patterson, T., & Richardson, R.B. (2005). The Eco-efficiency of Tourism. *Ecological Economics*, 54 (4), 417–434.

Gössling, S., Scott, D., & Hall, C.M. (2013). Challenges of Tourism in a Low-carbon Economy. *Wiley Interdisciplinary Reviews: Climate Change*, 4 (6), 525–538.

Hochman, G., & Timilsina, G.R. (2017). Energy Efficiency Barriers in Commercial and Industrial Firms in Ukraine: An Empirical Analysis. *Energy Economics*, 63, 22–30.

Im, K.S., Pesaran, M.H., & Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics*, 115 (1), 53–74.

Jollands, N., Waide, P., Ellis, M., Onoda, T., Laustsen, L., Tanaka, K., T'Serclaes, P., Barnsley, I., Bradley, R., & Meier, A. (2010). The 25 IEA Energy Efficiency Policy Recommendations to the G8 Gleneagles Plan of Action. *Energy Policy*, 38 (11), 6409–6418.

Lee, J.W. (2013). The Contribution of Foreign Direct Investment to Clean Energy Use, Carbon Emissions and Economic Growth. *Energy Policy*, 55, 483–489.

Levin, A., Lin, C.F., & Chu, C. (2002). Unit Root Tests in Panel Data: Asymptotic and Finite-sample Properties. *Journal of Econometrics*, 108 (1), 1–24.

Liu, W., & Lin, B. (2018). Analysis of Energy Efficiency and its Influencing Factors in China's Transport Sector. *Journal of Cleaner Production*, 170, 674–682.

Long, J.E. (1993). An Econometric Analysis of Residential Expenditures on Energy Conservation and Renewable Energy Sources. *Energy Economics*, 15 (4), 232–238.

Maddala, G.S., & Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and A New Simple Test. *Oxford Bulletin of Economics and Statistics*, 61 (S), 631–652.

Mielnik, O., & Goldemberg, J. (2002). Foreign Direct Investment and Decoupling between Energy and Gross Domestic Product in Developing Countries. *Energy Policy*, 30 (2), 87–89.

Mills, B., & Schleich, J. (2012). Residential Energy-efficient Technology Adoption, Energy Conservation, Knowledge, and Attitudes: An Analysis of European Countries. *Energy Policy*, 49, 616–628.

Nair, G., Gustavsson, L., & Mahapatra, K. (2010). Factors Influencing Energy Efficiency Investments in Existing Swedish Residential Buildings. *Energy Policy*, 38 (6), 2956–2963.

Paramati, S.R., Alam, M.S., & Lau, C.K.M. (2018). The Effect of Tourism Investment on Tourism Development and CO_2 Emissions: Empirical Evidence from the EU Nations. *Journal of Sustainable Tourism*, 26 (9), 1587–1607.

Pesaran, M.H., Shin, Y., & Smith, R.J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16 (3), 289–326.

Raza, S.A., Sharif, A., Wong, W.K., & Karim, M.Z.A. (2017). Tourism Development and Environmental Degradation in the United States: Evidence from Wavelet-based Analysis. *Current Issues in Tourism*, 20 (16), 1768–1790.

Sbia, R., Shahbaz, M., & Hamdi, H. (2014). A Contribution of Foreign Direct Investment, Clean Energy, Trade Openness, Carbon Emissions and Economic Growth to Energy Demand in UAE. *Economic Modelling*, 36, 191–197.

Scott, D., Gössling, S., Hall, C.M., & Peeters, P. (2016). Can Tourism Be Part of the Decarbonized Global Economy? The Costs and Risks of Alternate Carbon Reduction Policy Pathways. *Journal of Sustainable Tourism*, 24 (1), 52–72.

Shiftan, Y., Kaplan, S., & Hakkert, S. (2003). Scenario Building as a Tool for Planning a Sustainable Transportation System. *Transportation Research Part D: Transport and Environment*, 8 (5), 323–342.

Stephan, A., & Stephan, L. (2016). Life Cycle Energy and Cost Analysis of Embodied, Operational and User-transport Energy Reduction Measures for Residential Buildings. *Applied Energy*, 161, 445–464.

Sun, Y.Y. (2016). Decomposition of Tourism Greenhouse Gas Emissions: Revealing the Dynamics between Tourism Economic Growth, Technological Efficiency, and Carbon Emissions. *Tourism Management*, 55, 326–336.

United Nations Environment Program (2011). *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – A Synthesis for Policy Makers*. Nairobi: United Nations Environment Program (www.unep.org/greeneconomy).

Yuan, R., Zhao, T., & Xu, J. (2017). A Subsystem Input–output Decomposition Analysis of CO_2 Emissions in the Service Sectors: A Case Study of Beijing, China. *Environment, Development and Sustainability*, 19 (6), 2181–2198.

Zhang, L., & Gao, J. (2016). Exploring the Effects of International Tourism on China's Economic Growth, Energy Consumption and Environmental Pollution: Evidence from a Regional Panel Analysis. *Renewable and Sustainable Energy Reviews*, 53, 225–234.

Zheng, Y., Qi, J., & Chen, X. (2011). The Effect of Increasing Exports on Industrial Energy Intensity in China. *Energy Policy*, 39 (5), 2688–2698.

Table 1
Summary Statistics on the Individual OECD Economies (1995–2012)

Country	TEI	REI	OEI	FDI	PI	TO	TI
Australia	15.78	51.13	3.77	2.92	46699.59	40.41	13385.04
Austria	15.65	80.75	3.16	3.99	43288.93	88.73	3883.32
Canada	26.22	108.89	5.95	3.19	44646.72	70.17	7339.84
Chile	14.30	49.74	3.07	7.09	10804.07	65.22	2120.42
The Czech Republic	8.70	67.76	4.48	5.43	16941.53	108.69	1605.53
Denmark	11.58	75.26	2.73	3.16	56302.24	85.98	2506.11
Estonia	8.01	73.77	4.99	9.09	12628.78	139.49	315.09
Finland	12.04	91.78	5.57	3.65	42322.79	73.31	1214.29
France	12.21	68.91	2.89	2.29	38956.28	52.09	24956.07
Germany	11.14	69.69	2.87	2.27	39132.40	65.72	22486.43
Greece	14.11	55.43	2.66	0.63	25098.29	50.41	5989.94
Hungary	6.59	63.89	3.44	10.42	11675.08	129.84	1043.67
Iceland	12.98	206.15	8.47	3.49	39107.21	78.88	357.62
Ireland	14.41	89.54	2.67	13.07	44828.61	161.10	3805.51
Israel	14.95	58.37	2.59	3.16	27434.09	70.13	2136.12
Italy	7.80	54.19	2.53	1.01	35879.32	49.36	14170.45
Japan	8.18	42.41	2.89	0.15	43134.77	24.28	27077.45
Korea Republic	18.81	39.35	3.93	1.07	17529.55	75.13	7137.29
Latvia	8.41	63.97	4.91	4.34	9340.55	93.63	183.20
Mexico	14.69	31.54	2.46	2.67	8597.47	54.33	2948.50
The Netherlands	8.12	62.72	3.06	20.39	46793.08	123.92	3891.99
New Zealand	19.92	39.14	4.10	1.63	31465.60	59.53	1830.08
Norway	8.57	81.47	2.73	3.16	83980.46	70.60	2330.80
Poland	7.62	60.33	4.12	3.62	9798.98	67.44	2251.81
Portugal	14.57	34.62	2.69	3.35	21325.46	65.38	2814.43
Slovenia	17.82	70.18	4.04	1.75	20523.89	113.26	447.32
Spain	15.06	39.82	2.56	3.05	29048.73	53.93	17104.48
Sweden	10.17	71.13	4.19	5.74	47002.52	81.20	2081.00
Switzerland	7.62	77.98	2.31	4.42	68997.85	100.01	3059.48
Turkey	4.91	52.69	2.58	1.29	9227.45	47.02	8337.41
United Kingdom	9.79	71.27	2.87	4.42	36778.60	53.34	16229.86
United States	31.01	98.41	4.18	1.69	45930.16	25.32	135466.36
Panel average	12.87	68.82	3.61	4.30	33288.16	76.18	10640.84

Note: The summary statistics were calculated using before the log conversion data.

Table 2
Compounded Annual Average Growth Rates on the Individual OECD Economies (1995–2012)

Country	TEI	REI	OEI	FDI	PI	TO	TI
Australia	–1.64	–0.20	–1.73	0.76	1.89	0.69	4.32
Austria	0.22	–0.47	–0.52	2.72	1.54	2.41	0.61
Canada	–1.62	–0.90	–1.52	3.17	1.45	–0.57	4.08
Chile	–2.34	0.77	–0.89	5.97	3.17	1.21	9.86
Czech Republic	1.46	–0.81	–2.78	0.30	2.22	3.16	3.63
Denmark	–2.49	–0.50	–1.41	–5.29	0.97	2.30	2.46
Estonia	–2.44	1.14	–3.72	2.94	4.64	0.97	7.50
Finland	–11.99	–0.67	–1.62	5.15	2.07	1.27	1.72
France	–0.67	0.12	–1.21	–1.01	1.05	1.76	2.12
Germany	–3.33	–1.09	–1.53	8.00	1.35	3.84	3.40
Greece	–3.48	2.06	–0.71	–0.71	0.76	2.88	–0.01
Hungary	–0.28	–1.16	–2.29	–1.21	2.18	4.28	0.49
Iceland	–4.40	–3.01	–0.01	N/A	1.94	2.78	0.54
Ireland	–0.81	0.10	–2.57	12.76	2.86	2.06	6.87
Israel	–1.80	1.21	–1.31	5.06	1.68	0.75	2.12
Italy	–2.15	0.40	–0.42	–26.35	0.34	1.14	1.68
Japan	–1.91	–0.18	–1.06	14.92	0.64	3.44	–0.02
Korea	–5.27	2.56	–2.23	5.06	3.68	4.16	1.64
Latvia	–3.25	–0.87	–3.84	1.18	5.26	3.06	13.34
Mexico	–1.44	–1.80	–0.76	–2.44	1.42	2.05	10.76
Netherlands	–12.72	–0.80	–1.56	14.00	1.50	1.98	–0.49
New Zealand	–1.85	–0.35	–1.66	–4.48	1.46	0.01	1.52
Norway	10.46	–0.61	–1.54	6.95	1.28	0.00	3.28
Poland	11.93	–1.07	–3.76	–3.06	4.08	4.05	4.49
Portugal	–2.30	–0.23	–0.47	17.25	0.93	1.33	4.66
Slovenia	–2.23	–0.23	–1.55	–11.88	2.34	2.36	8.59
Spain	–1.72	0.92	–0.74	1.94	1.21	1.63	–0.27
Sweden	–2.71	–0.82	–2.78	–10.39	1.86	1.29	7.67
Switzerland	–1.13	–0.75	–1.31	9.28	1.11	2.67	0.05
Turkey	–3.12	–0.11	–0.43	6.27	2.81	0.93	3.49
UK	–14.31	–0.60	–2.43	0.39	1.39	1.12	3.30
US	–2.60	–0.94	–1.92	3.91	1.38	1.77	3.47
Panel average	–2.25	–0.28	–1.63	1.97	1.95	1.96	3.65

Notes: The compounded annual average growth rates were calculated using before the log conversion data; N/A implies that the begging value of the FDI was negative, so we did not calculate the compounded annual growth rate in Iceland.

Table 3

Results of the Panel Unit Root Tests

Method	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
	TEI		REI		OEI		FDI		PI		TO		TI	
Level														
Null: Unit root (assumes common unit root process)														
LLC test	–3.580***	0.000	–7.187***	0.000	–1.254	0.105	–8.412***	0.000	2.373	0.991	–5.766***	0.000	–3.960***	0.000
Breitung test	0.996	0.840	0.991	0.839	–1.003	0.158	–5.185***	0.000	7.226	1.000	–4.672***	0.000	–1.465*	0.071
Null: Unit root (assumes individual unit root process)														
IPS test	–4.463***	0.000	–3.359***	0.000	–1.620*	0.053	–7.042***	0.000	3.940	1.000	–4.169***	0.000	–5.873***	0.000
ADF test	131.844***	0.000	115.886***	0.000	87.252**	0.028	160.667***	0.000	45.831	0.958	112.329***	0.000	158.383***	0.000
PP test	153.709***	0.000	133.109***	0.000	70.970	0.257	147.871***	0.000	19.893	1.000	65.928	0.410	139.266***	0.000
First difference														
Null: Unit root (assumes common unit root process)														
LLC test	–17.022***	0.000	–16.403***	0.000	–15.813***	0.000	–19.908***	0.000	–11.206***	0.000	–15.950***	0.000	–13.410***	0.000
Breitung test	–5.833***	0.000	–4.431***	0.000	–6.645***	0.000	–15.816***	0.000	–7.263***	0.000	–12.252***	0.000	–7.495***	0.000
Null: Unit root (assumes individual unit root process)														
IPS test	–17.361***	0.000	–15.150***	0.000	–14.539***	0.000	–17.447***	0.000	–6.854***	0.000	–10.849***	0.000	–12.636***	0.000
ADF test	323.088***	0.000	302.514***	0.000	290.690***	0.000	334.308***	0.000	149.036***	0.000	218.220***	0.000	254.080***	0.000
PP test	431.910***	0.000	459.512***	0.000	378.669***	0.000	503.573***	0.000	206.990***	0.000	398.654***	0.000	392.822***	0.000

Notes: ***, **, and * indicate the rejection of the null hypothesis of a unit root at 1%, 5%, and 10% significance levels, respectively; the panel unit root tests were estimated by incorporating the constant and the trend variables in the models; the lag length was selected automatically based on the AIC approach.

Table 4

Results of the Long-run Estimations Using Panel ARDL Models

Variable	Coefficient	t-Statistic	Prob.
TEI = f (FDI, PI, TO, TI)			
FDI	–0.161***	–9.136	0.000
PI	0.513***	18.473	0.000
TO	–0.223***	–33.194	0.000
TI	–0.024**	–2.518	0.013
REI = f (FDI, PI, TO, TI)			
FDI	–0.023	–1.336	0.183
PI	0.246***	4.339	0.000
TO	–0.080**	–2.239	0.026
TI	–0.078***	–8.486	0.000
OEI = f (FDI, PI, TO, TI)			
FDI	–0.039***	–12.523	0.000
PI	–0.040*	–1.825	0.070
TO	–0.007	–0.655	0.513
TI	–0.042***	–9.222	0.000

Notes: ***, **, and * indicate the significance levels at the 1%, 5%, and 10%, respectively; the panel ARDL models were estimated by incorporating the constant and the trend variables; the lag length was chosen based on the AIC approach.

Table 5

Results of the Short-run Heterogeneous Panel Non-causalities

Null Hypothesis:	Zbar-Stat.	Prob.	Lags
Transportation energy intensity causalities			
FDI does not homogeneously cause TEI	–1.946*	0.052	3
TEI does not homogeneously cause FDI	4.108***	0.000	
PI does not homogeneously cause TEI	3.175***	0.002	2
TEI does not homogeneously cause PI	8.788***	0.000	
TO does not homogeneously cause TEI	0.479	0.632	3
TEI does not homogeneously cause TO	0.894	0.372	
TI does not homogeneously cause TEI	1.681*	0.093	1
TEI does not homogeneously cause TI	–0.914	0.361	
Residential energy intensity causalities			
FDI does not homogeneously cause REI	1.084	0.278	2
REI does not homogeneously cause FDI	1.124	0.261	
PI does not homogeneously cause REI	5.254***	0.000	2
REI does not homogeneously cause PI	0.816	0.414	
TO does not homogeneously cause REI	2.212**	0.027	2
REI does not homogeneously cause TO	–0.968	0.333	
TI does not homogeneously cause REI	3.306***	0.001	1
REI does not homogeneously cause TI	–1.411	0.158	
Overall energy intensity causalities			
FDI does not homogeneously cause OEI	1.375	0.169	2
OEI does not homogeneously cause FDI	–1.073	0.283	
PI does not homogeneously cause OEI	9.177***	0.000	2
OEI does not homogeneously cause PI	1.006	0.315	
TO does not homogeneously cause OEI	3.034***	0.002	2
OEI does not homogeneously cause TO	–1.025	0.305	
TI does not homogeneously cause OEI	0.513	0.608	2
OEI does not homogeneously cause TI	0.002	0.999	

Notes: ***, **, and * indicate the rejection of the null hypothesis of no causality at the 1%, 5%, and 10%, respectively; the causality test was applied on the first difference data series.